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WASTE ANALYSIS IN SKIN OINTMENT PRODUCTION USING LEAN MANUFACTURING AND VALUE STREAM MAPPING AT PT XYZ WATUDAKON PLANT

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Abstract:
The pharmaceutical industry works in accordance with the Good Manufacturing Practice (GMP), therefore, a portion of the waiting time during production processes cannot be eliminated. This research is intended to determine the types of waste, current state of value stream mapping, analysis of causes, and future state of production for the Salep Kulit XYZ 15 gram ointment at PT XYZ Plant Watudakon. A descriptive qualitative method using Value Stream Mapping (VSM) was employed in this research. Data was gathered from January to May 2026 by observation, stopwatch time measurement, interviews with five informant groups, and documentation. It shows that the total lead time was 102,780 minutes (71.38 days) with a value-added time of 3,120 minutes and PCE was 3.04%. "Waiting" and "inventory" were identified as the two most prevalent forms of waste. The "waiting" waste took place during raw material tests, finished goods tests, purchase order delays owing to cross unit arrears, import delays, and scheduling delays. Root causes include limited QC laboratory capacity, centralization of the ERP system, single-source supplier dependence, and scheduling non-integration. Four specific quantifiable GMP-compliant changes can be expected to cut lead time by 32.40 percent or 69,480 minutes and increase the PCE to 4.23 percent, with a fifth suggestion covering supply chain risks.

Keywords: Lean Manufacturing; Pharmaceutical Industry; Process Cycle Efficiency; Value Stream Mapping; Waste

INTRODUCTION

Manufacturing companies face increasing pressure to improve efficiency and productivity amid intensifying global competition. Waste in production processes increases operating costs, compromises product quality, and delays order fulfilment (Pierli et al., 2026). Production cost efficiency has also been examined in cost accounting, including target costing in small and medium-sized enterprises (Sidik & Nugroho, 2022). Lean manufacturing seeks to maximize customer value by systematically eliminating waste (Womack & Jones, 1996), while recent studies have connected lean practices with sustainability and digitalization (Lobo Mesquita et al., 2022; Yadav et al., 2023). Value Stream Mapping (VSM) is an essential technique for visualizing material and information flows, from raw material receipt to finished-goods production, together with processing and waiting times (Siagian & Saifudin, 2024). In pharmaceutical manufacturing, such inefficiencies must be addressed without compromising product quality or the regulatory safeguards that govern production.

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The effectiveness of VSM has been reported in ceramics (Siagian & Saifudin, 2024), automotive components (Prakoso et al., 2025), general manufacturing (Noviyana et al., 2024), new-energy vehicle body painting (Yang et al., 2025), rice processing (Oko et al., 2025), and metal casting (Sordan et al., 2025). Nevertheless, each industry encounters distinctive barriers to lean implementation (Silva et al., 2026). Pharmaceutical production must comply with Good Manufacturing Practice (GMP), as regulated by Indonesian Food and Drug Authority Regulation No. 7 of 2024, as amended by Regulation No. 7 of 2025 (BPOM, 2024, 2025). Mandatory quarantine and quality-control procedures cannot be eliminated; instead, efficiency improvements must focus on unnecessary queues and the execution of these activities.

Several sources of waste affect the production flow at PT XYZ Watudakon Plant. Under a centralized payment arrangement, outstanding liabilities of other plants may prevent suppliers from processing raw-material purchase orders. Geopolitical disruptions involving supplier countries and the Middle East have also complicated imports, delaying a product launch planned for February 2026. Following raw-material delivery, prolonged quality-control testing and inefficient production scheduling create additional waiting time.

Previous VSM research has primarily examined general manufacturing, automotive production, ceramics, and food processing; evidence from Indonesian state-owned pharmaceutical manufacturing under GMP requirements remains limited. This study distinguishes non-value-added (NVA) waste from necessary but non-value-added (NNVA) regulatory activities in semi-solid pharmaceutical production. It additionally considers centralized payment policies and geopolitical supply-chain exposure. Reducing waste and lead time may also improve organizational efficiency and sustainability, which are relevant to ESG research in Indonesia (Permatasari et al., 2024; Ikasari & Putikadea, 2026). Accordingly, this study identifies waste types, maps the current value stream, analyzes root causes, and designs a future-state process for 15-g XYZ Skin Ointment at PT XYZ Watudakon Plant. The contribution of this study is a GMP-sensitive VSM framework that links operational waste identification to feasible process improvements while separating mandatory quality-control activities from avoidable delays.

THEORETICAL REVIEW

This section reviews lean manufacturing principles, the seven types of waste, value stream mapping, activity classification, process efficiency measurement, GMP requirements, and prior research relevant to the study. Together, these concepts provide a framework for identifying waste, assessing its contribution to lead time, and developing improvements that respect mandatory pharmaceutical quality requirements.

Lean Manufacturing and the Seven Types of Waste

Lean manufacturing originated from the Toyota Production System (Ohno, 1988) and is based on five principles: value, value stream, flow, pull, and perfection (Womack & Jones, 1996). The seven conventional waste categories are transportation, inventory, motion, waiting, overproduction, overprocessing, and defects (Ohno, 1988; Siagian & Saifudin, 2024).

Value Stream Mapping and Activity Classification

VSM represents information and material flows through current-state and future-state maps (Siagian & Saifudin, 2024). Activities are classified as value-added (VA), non-value-added (NVA), or necessary non-value-added (NNVA). Although NNVA activities cannot simply be eliminated, their execution and associated waiting time can be optimized (Siagian & Saifudin, 2024; Prakoso et al., 2025).

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Process Cycle Efficiency and GMP Requirements

Process Cycle Efficiency (PCE) is the proportion of value-added time relative to total production lead time (Noviyana et al., 2024). In pharmaceutical manufacturing, quarantine and quality testing remain mandatory under Indonesian GMP requirements (BPOM, 2024, 2025); reductions in lead time must therefore preserve these regulatory procedures.

Previous Studies

Siagian and Saifudin (2024) identified overproduction, defects, and inventory in ceramic manufacturing, reporting a cycle-time reduction from 19,760.19 to 17,455.99 seconds. Prakoso et al. (2025) found that waiting represented 28% of motorcycle-holder production and reduced lead time from 627.1 to 460 seconds. Noviyana et al. (2024) reported a reduction in lead time from 14,415 to 9,875 seconds and an increase in PCE from 30.35% to 44.30%. Yang et al. (2025) recorded a 12.5% reduction in non-value-added time in new-energy vehicle painting, while Oko et al. (2025) observed a 61.24% lead-time reduction in rice milling. Sordan et al. (2025) developed a lean project framework to reduce lead time and non-value-added operations in metal casting.

In safety-critical environments, Marin-Garcia et al. (2021) noted that VSM has been used in healthcare, although its implications for sustainability performance indicators remain insufficiently addressed. Mengistu et al. (2025) showed that healthcare VSM metrics encompass time, efficiency, capacity, cost, patient safety, and satisfaction. By contrast, Silva et al. (2026) identified product changes, limited real-time visibility, and infrastructure constraints as barriers to lean implementation in Sri Lankan apparel manufacturing. Collectively, these studies demonstrate the usefulness of VSM for visualizing delays and developing operational improvements, while highlighting the need to adapt lean interventions to sector-specific constraints. The present study extends this perspective to GMP-regulated ointment production.

METHODS

This study adopted a descriptive qualitative approach in which the researcher served as the primary research instrument, data were collected through triangulation, and analysis proceeded inductively (Sugiyono, 2023). Similar approaches have been used to examine manufacturing phenomena in depth (Budianto et al., 2021) and cost-accounting practices through observation, interviews, and document analysis (Sidik & Nugroho, 2022). The study was conducted at PT XYZ Watudakon Plant, Kesamben District, Jombang Regency, East Java, from January to May 2026. The research focused purposively on a single product line, 15-g XYZ Skin Ointment, which accounts for approximately 35% of topical-product production volume, has considerable economic significance, and covers all stages of semi-solid dosage-form manufacturing. One batch consists of 100,000 tubes (1,500 kg). This design is suitable because it integrates observations and stakeholder explanations of operational bottlenecks with VSM-based documentation of material flows, waiting periods, and potential improvements.

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Primary data were collected through direct observation, stopwatch-based time measurements, and semi-structured interviews with five purposively selected informant groups (Table 1). Interviews were conducted throughout January–May 2026. Secondary data included production standard operating procedures, historical batch records, batch processing documents, certificates of analysis, quality-control reports, downtime reports, plant layouts, and GMP regulations. Data trustworthiness was supported by source triangulation, methodological triangulation (observation, interviews, and documentation), and member checking. Triangulation was used to compare observations and measured times with interview accounts and company records, while member checking supported the credibility of interpretations of production activities and operational constraints.

Table 1. Research informant groups

Code	Informant group	Tenure
N1	Production Manager	12 years
N2	Production Line Supervisor	8 years
N3	Procurement Department	6 years
N4	Production Operator	5 years
N5	Quality Control (QC) Staff	7 years

Source: Research data (processed), 2026.

Data analysis comprised three stages. First, operational data were examined and cycle times calculated. Second, a current-state map was developed (Rother & Shook, 1999; Hines & Taylor, 2000); the seven waste types were identified (Hines & Rich, 1997; Hines & Taylor, 2000); activities were classified as VA, NVA, or NNVA (Hines & Taylor, 2000); root causes were analyzed using the Five Whys technique (Ohno, 1988; Serrat, 2017; Daniyan et al., 2022); and a future-state map was designed (Rother & Shook, 1999; Hines & Taylor, 2000). Third, improvement recommendations were developed by integrating lean principles with GMP requirements. Value-stream performance was measured using PCE, as shown in Equation (1) (George, 2002; Daniyan et al., 2022).

$$\text{PCE} = (\text{Total VA time} / \text{Total lead time}) \times 100\% \quad (1)$$

In Equation (1), PCE denotes Process Cycle Efficiency (%); total VA time is the sum of value-adding activity durations (minutes), and total lead time includes processing and waiting time from raw-material ordering to product arrival at PT XYZ headquarters.

RESULTS AND DISCUSSION

Data were collected at PT XYZ Watudakon Plant between January and May 2026 through production-line observation, stopwatch measurements, interviews with informants N1–N5, and company document review. All reported times refer to one production batch of 15-g XYZ Skin Ointment.

Production Flow and Current-State Value Stream Map

Observations and interviews identified 12 production stages: raw-material ordering, raw-material delivery, incoming inspection and quarantine, raw-material testing, weighing and laboratory verification, manufacturing (base melting, mixing, homogenization, and cooling), filling and primary packaging, finished-product testing, finished-product quarantine, secondary and tertiary packaging, finished-goods storage, and shipment to PT XYZ headquarters in Jakarta. Information flow begins with demand forecasts issued by headquarters and converted into weekly production schedules by the Production Planning and Inventory Control (PPIC) department.

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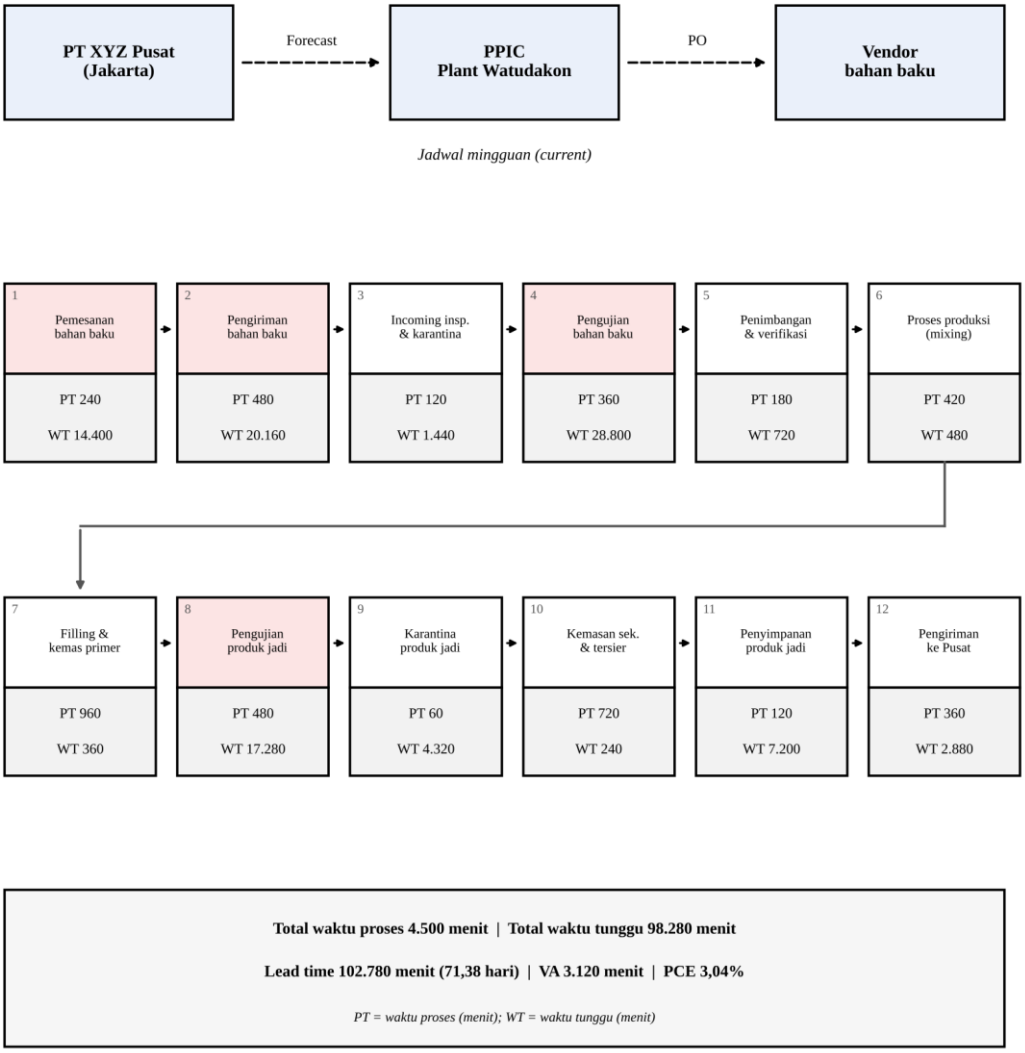


Figure 1. Current-state value stream map for 15-g XYZ Skin Ointment

Source: Research data (processed), 2026.

Total lead time was 102,780 minutes (71.38 days), consisting of 4,500 minutes of processing and 98,280 minutes of waiting. Waiting therefore accounted for 95.62% of total lead time. With 3,120 minutes (52 hours) of VA activity, current PCE was 3.04% (3,120/102,780 × 100%). Thus, 96.96% of the overall production timeline was devoted to waiting and activities that did not transform materials into finished products. The PCE was substantially below the 30.35% reported for general manufacturing by Noviyana et al. (2024).

Classification of VA, NVA, and NNVA Activities

Table 2. Definitions and treatment of VA, NVA, and NNVA activities

Category	Definition	Treatment in this study
VA	Activities that increase product value in the eyes of the final customer (Hines & Taylor, 2000).	Retained and included as the numerator in the Process Cycle Efficiency calculation (Equation 1).

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Category	Definition	Treatment in this study
NVA	Activities that add no value and are not necessary under existing conditions; pure waste (Hines & Taylor, 2000).	Primary elimination target because it is not required by any regulation.
NNVA	Activities that add no value but remain necessary under current supply-system conditions (Hines & Taylor, 2000).	Not removed because it is required by GMP (quarantine and quality testing); only queue time and execution methods are optimized .

Source: Definitions adapted from Hines and Taylor (2000); study-specific treatment developed by the authors (2026).

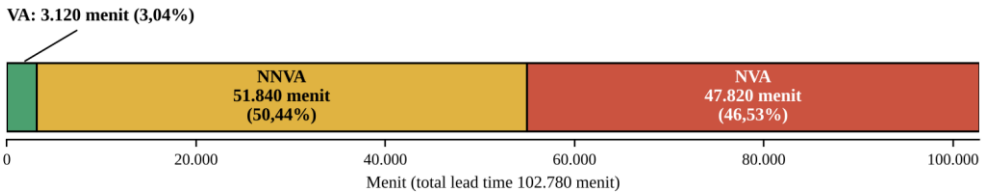
The classification applies to time spent, not merely to a list of activities. All minutes are allocated across VA, NNVA, and NVA categories so that their sum equals the total lead time of 102,780 minutes. This distinction is essential: PCE depends on VA time, whereas fully eliminable waste is restricted to NVA time. Mandatory NNVA activities cannot be eliminated, but their queues and execution can be improved.

The three-category activity classification was validated by the Production Manager (N1) and Quality Control staff member (N5). VA activities included melting the ointment base, homogenization, tube filling, and labeling. NNVA activities included microbiological testing, active-ingredient assays, material quarantine, cleanroom sanitation, and GMP-required batch records. NVA activities included delays caused by other plants' payment arrears, import disruptions, and unplanned intershift interruptions. Table 3 and Figure 2 present the activity composition. NNVA time corresponds to waiting during incoming inspection and quarantine, raw-material testing, finished-product testing, and finished-product quarantine (1,440 + 28,800 + 17,280 + 4,320 = 51,840 minutes). NVA comprises 46,440 minutes of waiting at other stages and 1,380 minutes of non-value-adding processing (4,500 − 3,120).

Table 3. Activity classification by lead time

Category	Examples at the plant	Time (minutes)	Percentage
VA	Base melting, homogenization, filling, and labeling	3.120	3,04%
NNVA	QC microbiological and active-content tests, quarantine, sanitation, and batch records	51.840	50,44%
NVA	Cross-plant payment arrears, import delays, and intershift interruptions	47.820	46,53%
Total		102.780	100,00%

Source: Research data (processed), 2026. Percentages may differ by 0.01% due to rounding.



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Figure 2. Lead-time composition by activity category

Source: Research data (processed), 2026.

Most waiting time (50.44%) was classified as NNVA. This finding is important because the underlying GMP-required activities cannot be removed, although their waiting times and execution may be optimized. Conversely, the 46.53% classified as NVA is a primary target for elimination because it is not required by regulation.

Identification of the Seven Types of Waste

Analysis of the seven TIMWOOD waste categories identified waiting and inventory as the dominant types of waste (Table 4).

Table 4. Summary of seven-waste findings

Waste	Manifestation at Watudakon Plant	Severity
Waiting	Awaiting QC release (materials and products), cross-plant PO holds, import delays, and scheduling gaps	High: 98,280 minutes of total waiting
Inventory	Materials in quarantine (20 days), bulk WIP (12 days), and finished-goods warehouse accumulation	High: an average of 2–3 batches on hold
Transportation	Repeated material movement between warehouse, weighing area, and mixing room	Moderate: 450 m per batch
Motion	Searching for equipment and batch records; duplicate manual records in the packaging room	Moderate: 45 minutes lost per shift
Overproduction	Batches exceed order quantities because of minimum batch-size requirements	Low: approximately 3% over-forecast stock
Overprocessing	Repeat sample tests required under GMP (NNVA)	Very low: required by GMP SOPs
Defects	Tube-seal leakage (0.8%) and incorrect filling weight (0.5%)	Moderate: average rework of 1.3% per batch

Source: Research data (processed), 2026.

Five major waiting points were identified. First, raw-material quality testing required 20 days (28,800 minutes) because QC laboratory capacity was insufficient. Second, packed products waited 12 days (17,280 minutes) for certificates of analysis. Third, raw-material purchase orders were delayed by 10 days (14,400 minutes) because suppliers automatically suspended orders owing to unpaid balances at other plants (NVA). Fourth, imported active ingredients were delayed by up to 14 days (20,160 minutes) because of interruptions to international shipping routes in the Middle East (external NVA). Fifth, mixing equipment remained idle for 480 minutes per batch while awaiting previously weighed liquid ingredients (NVA). Together, these points accounted for 81,120 minutes, equivalent to 82.54% of total waiting time. This finding is consistent with Prakoso et al. (2025), who identified waiting as a major form of waste.

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Inventory accumulated at three locations: approximately 15 raw-material containers in the quarantine warehouse, three to four holding tanks of bulk ointment work in progress occupying cleanroom space, and finished medicines awaiting release or dispatch. This accumulation tied up working capital and increased expiry risk. Other waste included the 180-m distance between the raw-material warehouse and weighing area, requiring manual trolley movements, and defects such as leaking tubes and incorrect fill weights (1.3% per batch), which created 180 minutes of manual sorting work. Overproduction and overprocessing were less prominent because of forecast-based planning and GMP-mandated testing.

Root Causes of Waste

A Five Whys analysis supported by purposive interviews identified root causes and grouped them by the organizational level responsible for control (Table 5).

Table 5. Root causes of waste

Waste	Root cause	Responsible authority
Waiting: raw-material testing	Limited HPLC/spectrophotometer equipment and analysts; sampling not prioritized by production schedule	Plant management
Waiting: finished-product testing	Seven-day microbiological incubation plus administrative queues for certificate-of-analysis issuance	Plant management
Waiting: cross-plant arrears	Centralized financial ERP blocks vendors if another plant has outstanding debt	Headquarters
Waiting: external factors	Dependence on a single overseas supplier and absence of safety stock for critical materials	Headquarters and plant
Waiting: scheduling gaps	PPIC scheduling is fragmented and not integrated in real time with released-material availability	Plant management
Excess inventory	Oversized batches and dispatch to headquarters only once every five days	Plant and logistics
Transportation	The raw-material warehouse is 180 m from the weighing area; manual trolley transfers create repeated movements to weighing and mixing areas	Plant management
Motion	Tools and batch records are not stored at their points of use, requiring searching; packaging records are duplicated manually	Plant management
Overproduction	Minimum batch size exceeds forecast-based order quantities, resulting in approximately 3% over-forecast stock	Headquarters and plant
Overprocessing	Repeat sample testing is mandatory under GMP SOPs (NNVA) and therefore cannot be eliminated	GMP regulator (BPOM)
Defects	Filling equipment lacks automatic sealing sensors; tube leakage (0.8%) and incorrect fill weights (0.5%) require manual sorting	Plant management

Source: Research data (processed), 2026.

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Transportation waste primarily resulted from the 180-m separation between the raw-material warehouse and weighing area. Motion waste arose from searching for tools and batch documentation and duplicate manual recording in packaging operations. Overproduction stemmed from minimum batch quantities exceeding forecast-based order requirements, producing approximately 3% excess forecast stock. Overprocessing resulted from repeat testing mandated by GMP and was therefore classified as NNVA. Defects mainly reflected the absence of automated sealing sensors on filling equipment. Four of these categories—transportation, motion, overproduction, and overprocessing—were not assigned individual improvement proposals because their severity was relatively low and they were less directly associated with major lead-time delays; moreover, mandatory testing cannot be eliminated.

These problems created a reinforcing cycle. Payment arrears and import disruptions affected weighing schedules; schedule changes caused raw materials to remain in quarantine; and this, in turn, contributed to testing queues in the QC laboratory. These interdependent causes informed a future-state design focused on reducing avoidable queues and improving coordination without changing compulsory product-quality controls.

Future-State Map Design

The proposed future state was developed according to lean principles (Womack & Jones, 1996), while maintaining compliance with BPOM Regulation No. 7 of 2024 and Regulation No. 7 of 2025. Five GMP-compatible improvement proposals are summarized in Table 6 and illustrated in Figure 3.

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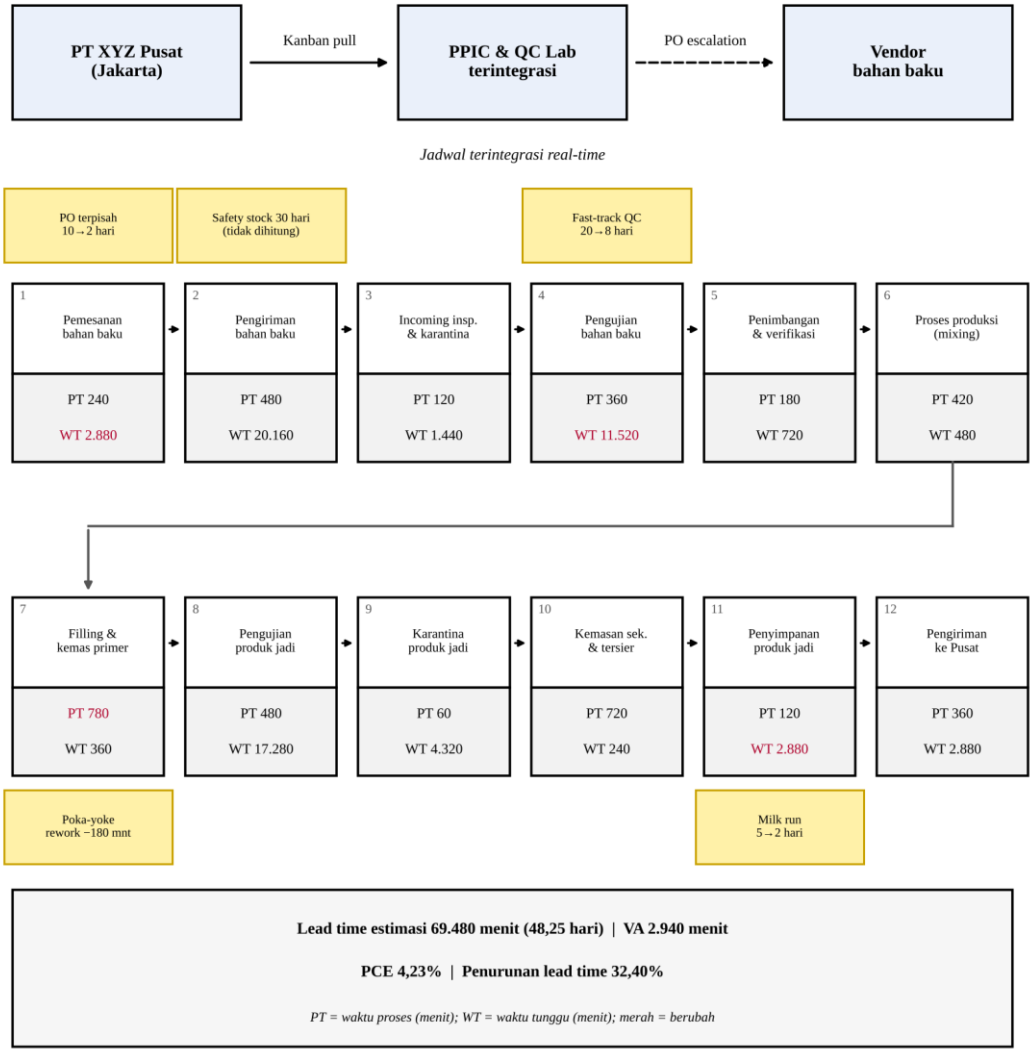


Figure 3. Estimated future-state value stream map for 15-g XYZ Skin Ointment

Source: Authors' proposed design based on research data (2026).

Table 6. Recommendations and GMP compliance considerations

Recommendation	Lean principle	GMP considerations	Expected impact
Fast-track QC: integrate QC sampling schedules with PPIC weighing schedules	Flow	Test types and parameters are maintained; only laboratory work sequence changes	Reduce raw-material testing waits from 20 to 8 days
Cross-plant PO mitigation: escalation mechanism and separate purchase-order accounts in ERP	Information flow	Does not alter BPOM-mandated procedures	Reduce PO holds from 10 to 2 days

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Recommendation	Lean principle	GMP considerations	Expected impact
Buffer stock and dual sourcing: 30-day safety stock for imported active ingredients	Pull	Alternative suppliers must undergo GMP supplier qualification	Reduce stockouts caused by geopolitical disruptions (excluded from lead-time estimate)
Poka-yoke: automated tube-seal sensors on filling machines	Perfection	Filling machines require requalification	Reduce defects from 1.3% to below 0.2%; save 180 minutes of rework
Milk run: dispatch QA-released products to headquarters every two days	Pull	Only products formally released by QA may be dispatched	Reduce storage waiting from five to two days

Source: Research data (processed), 2026.

The recommendations in Table 6 address problems identified in Tables 4 and 5. The first three proposals primarily concern waiting, the fourth addresses defects, and the fifth targets inventory accumulation.

First, fast-track QC targets the 20-day (28,800-minute) wait for raw-material analysis, the largest identified waiting component. Its root causes are limited HPLC/spectrophotometer availability, insufficient analysts, and sampling plans that are not prioritized according to production schedules (Table 5). The recommendation reduces NNVA waiting and raw materials held in quarantine by aligning QC sampling priorities with PPIC schedules. It changes laboratory sequencing without eliminating required tests or reducing sampling parameters and is therefore compatible with GMP.

Second, cross-plant purchase-order mitigation addresses the 10-day (14,400-minute) order hold caused by supplier credit restrictions linked to unpaid liabilities at other plants. The centralized enterprise resource planning (ERP) financial system prevents purchase orders from being processed when another plant has outstanding balances (Table 5). This delay is classified as NVA and can be targeted for elimination because it is not a regulatory requirement.

Third, buffer stock and dual sourcing address the 14-day (20,160-minute) import disruption caused by international supply-chain interruptions in the Middle East, which delayed the planned February 2026 product launch. The underlying vulnerability is dependence on one overseas supplier for critical materials without safety stock (Table 5). The proposal maintains a 30-day buffer specifically for imported active ingredients, limiting additional inventory to high-risk materials.

Fourth, poka-yoke aims to prevent filling defects, including tube-seal leakage (0.8%) and incorrect fill weight (0.5%). These defects totaled 1.3% per batch and required 180 minutes of manual operator sorting. The proposal uses automatic sealing sensors to prevent errors at source, consistent with the error-proofing approach described by Hines and Taylor (2000).

Fifth, the milk-run proposal addresses accumulation of released finished goods in the warehouse because dispatches to headquarters occur only every five days (7,200 minutes) and batches are relatively large (Table 5). Dispatching every two days reduces unnecessary storage and NVA waiting without changing manufacturing or GMP release procedures.

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The estimated impact of the proposed changes was calculated by adjusting stage durations (Table 7). Buffer stock and dual sourcing were excluded from the normal-state lead-time estimate because they primarily mitigate supply disruption rather than shorten routine processing. The other four proposals were projected to reduce lead time by 33,300 minutes, from 102,780 minutes (71.38 days) to 69,480 minutes (48.25 days), a decrease of 32.40%.

Table 7. Estimated lead-time reduction by improvement proposal

Proposal	Affected stage	Current (minutes)	Future (minutes)	Reduction (minutes)
Fast-track QC	Raw-material testing (waiting)	28,800	11,520	17,280
Cross-plant PO mitigation	Raw-material ordering (waiting)	14,400	2,880	11,520
Milk run	Finished-goods storage (waiting)	7,200	2,880	4,320
Poka-yoke	Filling and primary packaging (processing)	960	780	180
Buffer stock and dual sourcing	Raw-material shipment	20,160	20,160	0
Total				33,300

Source: Research data (processed), 2026.

VA time was projected to decrease to 2,940 minutes because 180 minutes of rework would be eliminated; consequently, PCE would increase from 3.04% to 4.23%. This projected improvement does not imply the removal of mandatory GMP testing and quarantine activities.

Table 8. Comparison of current-state and future-state performance

Indicator	Current state	Future state
Total lead time (minutes)	102,780 (71.38 days)	69,480 (48.25 days)
Total processing time (minutes)	4,500	4,320
Total waiting time (minutes)	98,280	65,160
Total VA time (minutes)	3,120	2,940
NNVA time (minutes)	51,840 (50.44%)	34,560 (49.74%)
NVA time (minutes)	47,820 (46.53%)	31,980 (46.03%)
Process Cycle Efficiency	3.04%	4.23%
Raw-material testing wait	20 days	8 days
Cross-plant PO hold	10 days	2 days
Finished-product storage	5 days	2 days
Defect rate	1.3%	< 0.2%

Source: Research data (processed), 2026. NNVA and NVA percentages represent their shares of total lead time.

Discussion

The findings confirm waiting as the primary source of waste. However, the key distinction in pharmaceutical manufacturing is that a substantial portion of waiting is connected to mandatory GMP procedures. Thus, the objective is not to eliminate all waiting-related activities indiscriminately but to distinguish necessary compliance operations from avoidable queues and administrative delays. This difference is fundamental when applying lean manufacturing in regulated production. This interpretation is consistent with VSM studies identifying waiting as a central improvement opportunity (Prakoso et al., 2025; Noviyana et al., 2024), but pharmaceutical production requires an additional distinction between regulatory necessities and removable inefficiencies.

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Reducing unnecessary waiting and rework may also improve operational efficiency and contribute to cost and sustainability performance, consistent with broader studies of lean manufacturing and ESG-related management (Lobo Mesquita et al., 2022; Permatasari et al., 2024). Nevertheless, reductions in time do not directly establish realized financial savings without corresponding cost measurement.

Lean implementation depends on operational context (Silva et al., 2026). At PT XYZ Watudakon Plant, the most important constraints include laboratory capacity, centralized procurement and finance arrangements, exposure to international suppliers, and the need to preserve quality assurance. Consequently, improvement requires coordination between plant management, headquarters, QC, procurement, and logistics rather than isolated changes at one workstation.

The proposed changes provide benefits across three dimensions of plant operations. Operationally, shorter queues may support more reliable production schedules and deliveries. Financially, lower work-in-progress and finished-goods inventories may reduce working-capital pressure. From a quality and compliance perspective, process improvements can be pursued while maintaining the testing, release, and traceability procedures required by GMP.

Overall, the future-state design provides management with a quantitative basis for prioritizing waiting-time reduction and process integration. Because projected results have not yet been implemented and verified in routine operations, the estimated improvements should be treated as planning targets rather than observed outcomes. Accordingly, implementation should be followed by routine monitoring to establish whether the anticipated improvements are achieved under actual production conditions.

CONCLUSION AND RECOMMENDATIONS

Seven types of waste were identified in 15-g Skin Ointment production at PT XYZ Watudakon Plant: waiting, inventory, transportation, motion, overproduction, overprocessing, and defects. Waiting and inventory were the most significant categories, particularly because of raw-material testing, finished-product testing, cross-plant purchase-order holds, import delays, and production scheduling.

Activity classification showed that VA time represented a relatively small proportion of total lead time, resulting in a current PCE of 3.04%. The estimated future-state measures could reduce total lead time from 102,780 to 69,480 minutes (32.40%) and increase PCE to 4.23%, while maintaining compulsory GMP activities.

The company should consider priority QC scheduling, separation or escalation mechanisms for cross-plant purchase orders, selective buffer stocks and qualified dual sourcing, automatic sealing sensors, and more frequent dispatch of released products. Implementation should involve the relevant authorities at plant and headquarters levels and be monitored against operational and GMP-compliance indicators.

This study was limited to one product line, and its future-state scenario represents a projection rather than an implementation outcome. Future research should validate the proposed improvements using operational data after implementation, examine associated costs and benefits, and evaluate whether similar results arise across other pharmaceutical product lines. For production management, the immediate priority is to coordinate QC capacity, procurement decisions, and production scheduling while safeguarding product quality and regulatory compliance.

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